



Section II: Planning Your Safe Room

Now that you better understand your risk from a tornado or hurricane, you can work with your builder/contractor to build a safe room to provide near-absolute protection for you, your family, or employees from these extreme windstorms. This section describes how extreme winds can damage a building, explains the basis of the safe room designs presented in this publication, and shows where you can build a safe room in your home or small business.

Building Damage

Extreme winds can cause several kinds of damage to a building. To understand what happens when extreme winds strike, you must first understand that tornado and hurricane winds are not constant. Wind speeds, even in these extreme-wind events, rapidly increase and decrease. An obstruction, such as a home, in the path of the wind causes the wind to change direction. This change in wind direction increases pressure on parts of the home. The combination of increased pressures and fluctuating wind speeds creates stress on the home that frequently causes connections between building components to fail.

For example, the roof covering, roof deck, or wall siding can be pulled off and the windows can be pushed into or suctioned out of a building. Figure II-1 shows how extreme winds can affect a building and helps explain why these winds cause buildings to fail. When wind is allowed to enter a building through a broken window, door, or roof section, that wind will act on the inside of a building much like air will act when forced into a balloon; it will push (or pull) on the walls and roof of the building from the inside. These forces within the building, added to the wind forces that are still acting on the outside of a building, often result in failure of the building because it was not designed to resist the forces acting on both the inside and the outside of the building

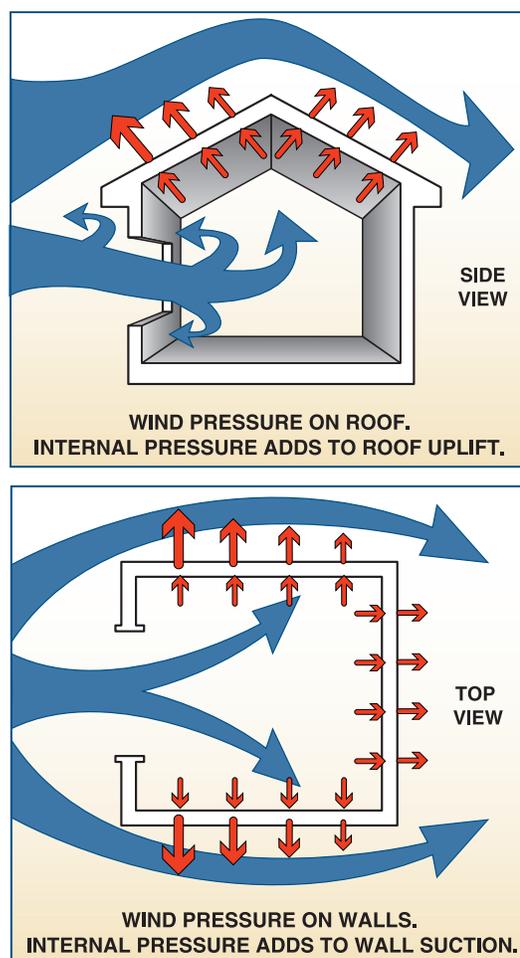


Figure II-1. Effect of extreme winds on building roof and walls



Buildings that fail under the effects of extreme winds often appear to have exploded, giving rise to the misconception that the damage is caused by unequal atmospheric or wind pressures inside and outside the building. This misconception has led to the myth that, during an extreme-wind event, the windows and doors in a building should be opened to equalize the pressure. In fact, opening a window or door allows wind to enter a building and increases the risk of building failure.



2" x 6" missile penetrating a refrigerator, midwest tornadoes of May 3, 1999

Damage can also be caused by flying debris (referred to as windborne missiles). If wind speeds are extreme enough, missiles can be thrown at a building with enough force to penetrate or perforate windows, walls, or the roof. For example, an object such as a 2" x 4" wood stud weighing 15 pounds, when carried by a 250-mph wind, can have a horizontal speed of 100 mph, which is enough force to penetrate or perforate most common building materials used in homes today. Even a reinforced masonry wall, which typically has hollow cells between reinforced cells, will be perforated unless it has been designed and constructed to resist debris impact during extreme winds. Because missiles can severely damage and even perforate windows, walls, and roofs, they threaten not only buildings but the occupants as well.



Palm tree pierced by plywood missile, Hurricane Andrew



DEFINITION

In this publication, missiles may be said to **penetrate** but not **perforate** the walls or roof of a safe room. For example, if a missile **penetrates** an exterior element of the safe room, this means the missile broke or damaged the exterior surface, but has not entered the safe room protected area. It is quite common for smaller missiles such as small stones, branches, and other lighter missiles to penetrate or imbed themselves into the exterior of the safe room and this is acceptable. However, the safe room walls, roof, and protected openings must not allow a missile to **perforate** these systems and allow the missile to enter into the safe room. When any portion of the safe room exterior is damaged such that a missile, or portion thereof, enters the protected area, the safe room exterior has been perforated and this is not acceptable.



Basis of Safe Room Design

The purpose of a safe room is to provide a space where you, your family, or employees can survive a tornado or hurricane with little or no injury. For tornado-prone areas, you should locate your safe room so that you can reach it as quickly as possible from all parts of your home or business. In hurricane-prone areas, the safe room should not be built where it can be flooded during a hurricane. Your safe room should be readily accessible from all parts of your home or small business and should be free of clutter. To provide near-absolute protection for the occupants during extreme windstorms, the safe room must be adequately anchored to the home's foundation to resist overturning and uplift. The connections between all parts of the safe room must be strong enough to resist failure, and the walls, roof, and door must resist perforation by windborne missiles.

Extensive testing by Texas Tech University and other wind engineering research facilities has shown that walls, ceilings, and doors commonly used in building construction to meet minimum building code requirements for standard building construction cannot withstand the impact of missiles carried by extreme winds. The safe room designs in this publication account for these findings by specifying building materials and combinations of building materials that will resist perforation by missiles in extreme winds.

Most homes, even new ones constructed according to current building codes, do not provide adequate protection for occupants seeking life-safety protection from tornadoes. Homes built to the modern building codes in hurricane-prone areas, such as windborne debris regions better resist wind forces and windborne debris impacts from hurricanes. However, a tornado or hurricane can



Missile (debris) launcher, Wind Engineering Research Center (WERC), Texas Tech University



2" x 4" wood stud launched at 100 mph pierces unreinforced masonry wall, WERC, Texas Tech University



cause wind and windborne debris loads on a home or small business that are much greater than those on which building code requirements are based. Only specially designed and constructed safe rooms, which are voluntarily built above the minimum code requirements of the IBC and IRC to the criteria of this publication, FEMA 361, or the ICC-500, offer life-safety occupant protection during a tornado or strong hurricane. The prescriptive designs provided in this publication provide near-absolute protection from winds and windborne debris associated with tornadoes or hurricanes.

**NOTE**

This publication provides FEMA safe room designs that meet or exceed the minimum shelter design requirements from the ICC-500 Storm Shelter Standard. The safe room designs in this publication are applicable for both tornado and hurricane hazards for the residential shelter and small community shelter (<16 occupants) design criteria identified in the ICC-500. The safe room design wind speed used is 250 mph and it has been designed as a “partially enclosed building” per ASCE 7 so as to meet the requirements of both residential and community safe rooms for tornado and hurricane hazards. Further, the missile resistance is based upon the 15-lb 2”x4” board missile traveling horizontally at 100 mph (again, the most restrictive criteria for both tornado and hurricane hazards). For additional design criteria and information for residential safe rooms, see the notes on the safe room plans in this publication and the design requirements for residential safe rooms in Chapter 3 of FEMA 361, *Design and Construction Guidance for Community Safe Rooms*.

The safe room designs provided in this publication are based on wind speeds that are rarely exceeded in the United States. Therefore, a safe room built according to these designs is expected to withstand the forces imposed on it by extreme winds without failing; this statement applies to both materials and connections used within the safe room. The intent of the designs is not to produce a safe room that will always remain completely undamaged, but rather a safe room that will enable its occupants to survive an extreme windstorm with minor or no injuries.

It is very important to note that predicting the exact strength of tornadoes and hurricanes is impossible. That is another reason why the safe room designs in this publication are based on extreme-wind speeds and why the primary consideration is life safety.

Designing a building, or portion of a building, to resist damage from more than one natural hazard requires different, sometimes competing, approaches. For example, building a structure on an elevated foundation to raise it above expected flood levels can increase its vulnerability to wind and seismic damage. These design approaches need to be thoroughly considered. In flood-prone areas, careful attention should be given to the warning time, velocity, depth, and duration of floodwaters. These flooding characteristics can have a significant bearing on the design and possibly even the viability of a safe room. Your local building official or licensed professional engineer or architect can provide you with information about other natural hazards that affect your area and can also recommend appropriate designs.



Safe Room Size

The amount of floor area per person that your safe room must provide depends partly on the type of windstorm from which the safe room is intended to protect you. Tornadoes are not long-lasting storms, so if you are relying on your safe room only for tornado protection, you will not need to stay in the safe room for as long a timeframe as you would for a hurricane. As a result, comfort is not of great concern, and a safe room that provides at least 5 square feet of floor area per person (note that wheelchair and bedridden occupants will require more space) will be big enough. This allocation of space per occupant also meets the minimum sizing requirements set forth in the ICC-500 for residential and small community tornado shelters.

When the safe room is intended to provide near-absolute protection from storms such as hurricanes, which can last for 24 hours or more, the comfort of the occupants should be considered. For this type of safe room, the recommended amount of floor area per person (standing or seated, not wheelchair or bedridden) varies from 7 to 20 square feet, depending upon the classification of the safe room. The minimum sizing requirement set forth in the ICC-500 for residential hurricane shelters is 7 square feet per occupant, while for small community shelters 20 square feet per occupant is specified. Necessities, such as water and toilet facilities, should also be provided in the small community safe rooms to maintain compliance with the FEMA 361 criteria and ICC-500 requirements. The safe room designs in this guide may have a minimum floor area of 48 square feet and a wall length of 6 feet. A safe room of that size used for hurricane protection could accommodate up to six people in reasonable comfort while maintaining compliance with the FEMA 361 criteria and ICC-500 requirements. The maximum floor dimensions in the safe room designs provided in this guide are shown to be 14 feet by 14 feet square, providing 196 square feet of safe room space. This amount of space could provide safe room protection for nine occupants at the ICC-500 square footage requirements for a small community hurricane shelter. If you plan to build a safe room with any wall longer than 14 feet, or with a wall height greater than 8 feet, consult a licensed professional engineer or architect.



NOTE

The safe room designs in this publication are applicable for any on-site construction. However, in a modular home, the safe room location would be limited to the basement or the below-ground module unless a separate foundation was designed and installed for the safe room. A modular home is a home constructed of modular units that have been built elsewhere, brought to the site, and installed on a permanent foundation.



NOTE

Consult FEMA 361 or the ICC-500 for guidelines and requirements on how to identify the net usable floor space for a safe room design from the publication if it is to be used as a small community safe room. Hard fixtures (sinks, bathtubs, etc.) and furnishings reduce the square footage within a safe room that is available for protecting occupants.



Foundation Types

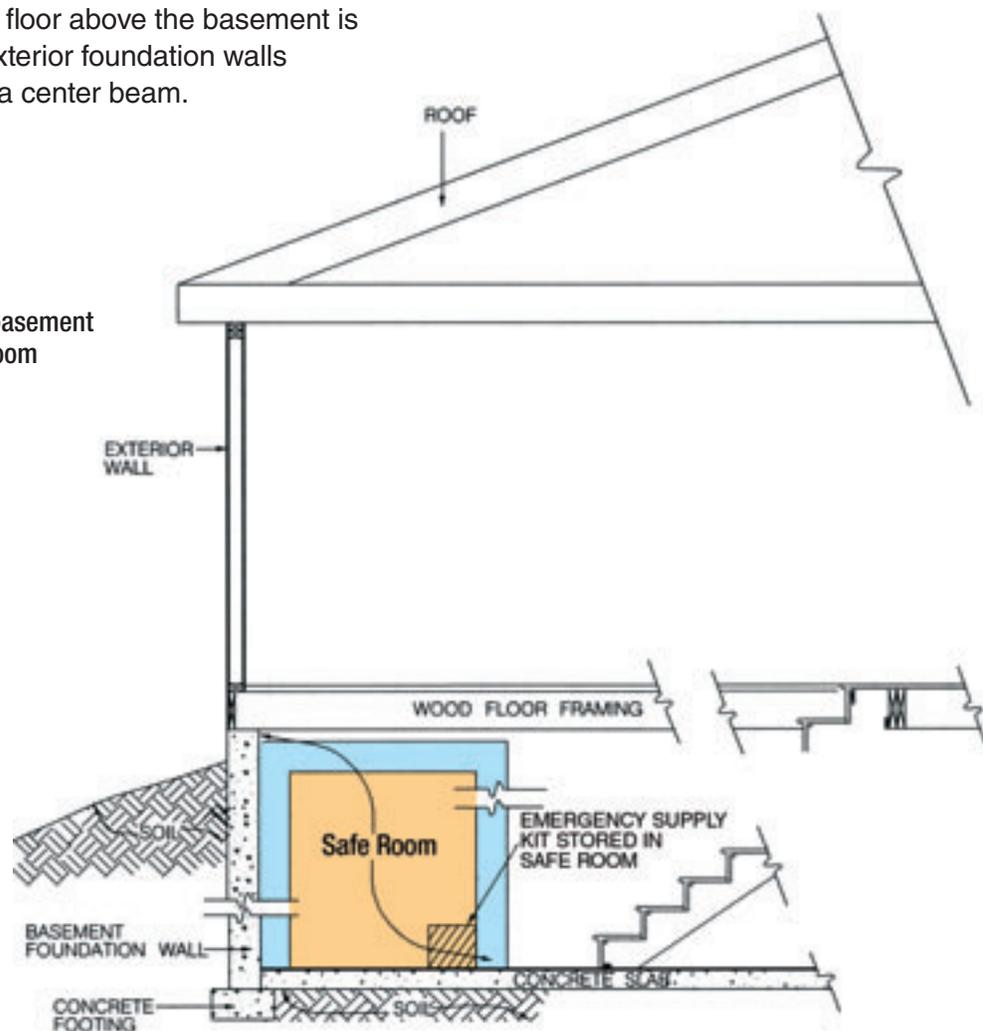
Homes and other buildings vary in construction type as well as foundation type. Buildings constructed may have heavy walls systems, such as masonry or concrete, or they may have light walls systems constructed from wood framing, metal stud framing, or structural insulated panels (SIPs). Regardless of the structure above, the following types of foundations may be suitable for the installation of a safe room:

- Basement
- Slab-on-grade
- Crawlspace or pile (however, prescriptive solutions for pile foundations are not provided in the drawings included in this publication)

Basement Foundation Applications

A home on a basement foundation (see Figure II-2) is usually built on a foundation constructed of cast-in-place concrete or concrete masonry units (CMUs). Most concrete foundations are reinforced with steel bars or straps, but many CMU foundation walls have no steel reinforcement. The framing for the floor above the basement is supported by the exterior foundation walls and sometimes by a center beam.

Figure II-2.
Cross-section: typical basement
foundation, with safe room





In a new or existing home with a basement, the safe room should be built in the basement. You can build the safe room as an entirely separate structure with its own walls, or you can use one or more of the basement walls as walls of the safe room. If you use the existing basement walls, they will have to be specially reinforced. Typical reinforcement techniques used in residential basement walls will not provide sufficient protection from missiles and resistance to extreme-wind loads. In new construction, your builder/contractor can reinforce the walls near the safe room during the construction of your home. Reinforcing the basement walls of an existing home is not practical.

The likelihood of missiles entering the basement is lower than for above-ground areas; however, there is a significant chance that missiles or falling debris will enter the basement through an opening left when a window, a door, or the first floor above has been torn off by extreme winds. Therefore, your basement safe room must have its own reinforced ceiling; the basement ceiling (the first floor above) cannot be used as the ceiling of the safe room. The safe room designs provided have considered that large, heavy loading from debris may be experienced by the safe rooms when a surrounding structure may collapse during an extreme-wind event. The roof decks of these safe rooms are designed to limit the damage that may be induced from these debris sources. Although the building may collapse around the safe room, it is still appropriate to install the safe room in the basement.

The least expensive type of safe room that can be built in a basement is a lean-to safe room, which is built in the corner of the basement and uses two basement walls. The lean-to safe room uses the fewest materials, requires the least amount of labor, and can be built more quickly than other types of basement safe rooms (see drawings B-01 and B-02).

In general, it is easier to add a basement safe room during the construction of a new home than to retrofit the basement of an existing home. If you plan to add a basement safe room as a retrofitting project, keep the following points in mind:

- You must be able to clear out an area of the basement large enough for the safe room.
- Unless the exterior basement walls contain steel reinforcement as shown on the design drawings provided with this publication, these walls cannot be used as safe room walls since they are not reinforced to resist damage from missiles and uplift from extreme winds.
- Exterior basement walls that are used as safe room walls must not contain windows, doors, or other openings in the area providing protection.
- The safe room must be built with its own ceiling, so that the occupants will be protected from missiles and falling debris.

Slab-on-Grade Applications

A slab-on-grade home or commercial building (see Figure II-3) is built on a concrete slab that is installed on compacted or natural soil. The concrete may be reinforced with steel that helps prevent cracking and bending. If you are building a new slab-on-grade home and want to install a safe room (of any material or type), it is recommended that the slab or foundation beneath the safe room wall be reinforced and thicker to ensure proper support and resistance to all loads



(gravity and wind loads). The thickened slab will act as a footing beneath the walls of the safe room to provide structural support. It will also help anchor the safe room so that it will stay in place during an extreme-wind event, even if the rest of the home is destroyed.

In an existing home, removing part of the slab and replacing it with a thickened section to support a safe room would involve extensive effort and disruption inside the home. Some safe room designs presented in the drawings will require a footing to be placed due to the weight of the safe room itself, but others may be secured to an existing slab provided it has reinforcing steel in the concrete. Therefore, building a safe room with concrete or concrete masonry walls in an existing slab-on-grade home may not be practical unless the existing slab can be shown to have reinforcement adequate to support the safe room. If reinforcement can be shown to be present, the designs provided in these plans may be retrofitted to certain reinforced slabs. Similarly, a wood-frame safe room may be constructed atop an existing, reinforced slab because its walls are not as heavy and do not require the support of a thickened slab; however, these lighter safe room designs are vulnerable to displacement by wind loads. A wood-frame safe room can be created from an existing room, such as a bathroom or closet, or built as a new room in an open area in the home, such as a garage. Whenever an existing slab is used as the foundation for a safe room, a structural engineer should evaluate the adequacy of the slab to resist the wind loads acting on the safe room.

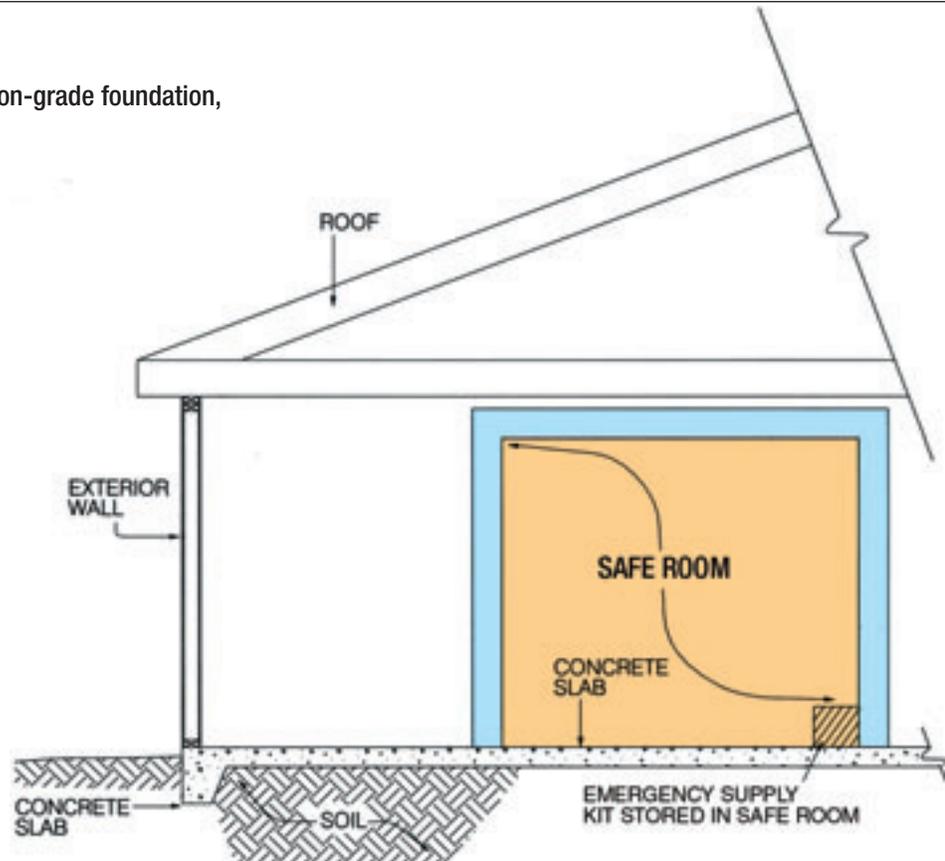
You can also build a safe room as an addition to the outside of a slab-on-grade home. This type of safe room must not only have proper footings, but also a watertight roof. Because a safe room built as an outside addition will be more susceptible to the impact of missiles, it should not be built of wood framing alone. Instead, it should be built of concrete or concrete masonry. Access to this type of safe room can be provided through an existing window or door in an exterior wall of the home.

In general, it is easier to add a safe room during the construction of a new slab-on-grade home than to retrofit an existing slab-on-grade home. If you plan to add a safe room to a slab-on-grade home as a retrofitting project, keep the following points in mind:

- The walls of the safe room must be completely separate from the structure of the home. Keeping the walls separate makes it possible for the safe room to remain standing even if portions of the home around it are destroyed by extreme winds.
- If you are creating your safe room by modifying a bathroom, closet, or other interior room with wood-frame walls, the existing walls and ceiling must be retrofitted or replaced with walls and a ceiling resistant to the impact of windborne missiles and other effects of extreme winds. In most cases, this means removing the sheathing, such as drywall or plaster, on either the inside, outside, or both sides of the walls and ceiling. Where possible, it is recommended that the shelter be built as a “new room” within the existing room in order to isolate the shelter from the home structure.
- If you intend to build a safe room with concrete or concrete masonry walls, a section of your existing slab floor may have to be removed and replaced with a thicker slab. As noted above, if this is necessary it may mean the retrofit may not be practical in the existing home.



Figure II-3.
Cross-section: typical slab-on-grade foundation,
with safe room



Crawlspace or Pile Applications

A home built on a crawlspace (see Figure II-4) usually has a floor constructed of wood framing. Along its perimeter, the floor is supported by the exterior foundation walls. The interior part of the floor is supported by beams that rest on a foundation wall or individual piers. Crawlspace foundation walls may be concrete, but are usually constructed from blocks of concrete masonry unit (CMU). They are often unreinforced and therefore provide little resistance to the stresses caused by extreme winds.

Building a safe room inside a home on a crawlspace foundation is more difficult than building a shelter inside a home on a basement or slab-on-grade foundation. The main reason is that the entire safe room, including its floor, must be separate from the framing of the home or the entire floor system and foundation of the home will be required to be constructed to support the extreme-wind loads acting on the safe room. In Figure II-4, a safe room is built inside the home or commercial building without using the floor system of the structure itself. In this option, the safe room has a separate concrete slab floor installed on top of earth fill and must be supported by steel reinforced concrete or CMU foundation walls. The floor system may be designed as open and elevated, but that design option is difficult to develop a prescriptive solution for and therefore is not provided in this publication. An alternative approach, which may be more economical, is to build an exterior safe room on a slab-on-grade foundation adjacent to an outside wall of the home and provide access through a door installed in that wall.

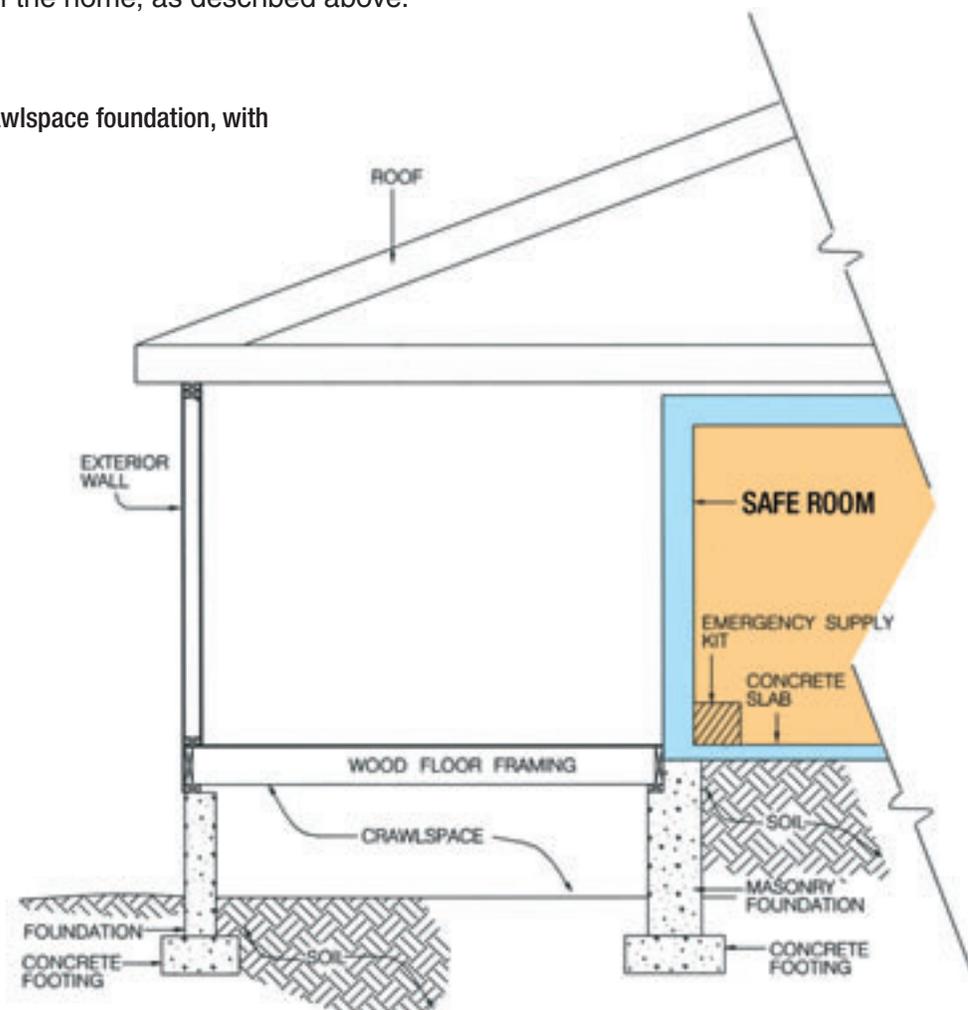


Ventilation in the area below the floor of the home is also an important issue. The wood-framed floor of a home on a crawlspace foundation is typically held 18 to 30 inches above the ground by the foundation walls for compliance with the building code. The space below the floor is designed to allow air to flow through so that the floor framing will not become too damp. It is important that the installation of the safe room not block this air flow.

In general, it is much easier to build a safe room inside a new crawlspace home than in an existing crawlspace home. If you plan to add a safe room to an existing crawlspace home as a retrofitting project, keep the following points in mind:

- The safe room must have a separate foundation. Building the foundation inside the home would require cutting out a section of the existing floor and installing new foundation members, fill dirt, and a new slab – a complicated and expensive operation that is often not practical.
- A more practical and more economical approach would be to build an exterior safe room, made of concrete or concrete masonry, on a slab-on-grade foundation adjacent to an outside wall of the home, as described above.

Figure II-4.
Cross-section: typical crawlspace foundation, with safe room



**WARNING**

It is also important to remember that FEMA does not support placing safe rooms offering protection against extreme-wind events where floodwaters have the potential to endanger occupants within the safe room. Although the ICC-500 allows the placement of residential shelters in areas subject to flooding, FEMA safe room design criteria for residential safe rooms significantly limit the placement of safe rooms in Special Flood Hazard Areas (SFHAs). A residential safe room may only be sited in mapped SFHA where no wave action or high-velocity water flow is anticipated. Therefore, the installation of a safe room in a home supported by piles, piers, or columns should be scrutinized for its location with respect to flood hazards. With building connectors commercially available, it is extremely difficult to economically and structurally separate the safe room from the elevated floor framing and ensure that the safe room will withstand the forces of extreme winds.

If your safe room is located where coastal or riverine flooding may occur during hurricanes, it should not be occupied during a hurricane. Further, a residential safe room should not be located in an area subject to storm surge inundation. Although occupying such a safe room during a tornado may be acceptable, provided that the safe room is located where it will not be flooded by rains associated with other storm and tornado events, it should not be used during a hurricane. A residential safe room sited in the SFHA should meet the flood-specific FEMA safe room design criteria listed below. Consult your local building official or local National Flood Insurance Program (NFIP) representative to determine whether your home or small business, or a proposed stand-alone safe room site, is susceptible to coastal or riverine flooding. In any case, the installation of any safe room in a hurricane-prone area should be coordinated with local emergency management and law enforcement to ensure that its use during extreme-wind events is not a violation of any local or state evacuation plan.

Certain safe room designs provided in this publication may be elevated several feet above existing grade (see drawing sheets for specific details). However, even though the safe room floor may be elevated, it should be located *outside* of the following high-risk flood hazard areas:

1. The Coastal High Hazard Area (VE zones) or other areas known to be subject to high-velocity wave action; or
2. Areas seaward of the Limit of Moderate Wave Action (LiMWA) where mapped, also referred to as the Coastal A Zone in ASCE 24-05; or
3. Floodways; or
4. Areas subject to coastal storm surge inundation associated with a Category 5 hurricane (where applicable, these areas should be mapped areas studied by the U.S. Army Corps of Engineers (USACE), NOAA, or other qualified sources).

**WARNING
(CONTINUED)**

If it is not possible to install or place a residential safe room outside the SFHA, the residential safe room may be placed in an area that has been determined by detailed study to be in an A, shaded X, or unshaded X Zone, but still outside of the high hazard areas identified above. In the instances when a residential safe room is needed in these flood-prone areas, the top of the elevated floor of the safe room should be elevated to the highest of the elevations specified below (see the appropriate Flood Insurance Study (FIS) or Flood Insurance Rate Map (FIRM)):

1. The minimum elevation of the lowest floor required by the floodplain ordinance of the community (if such ordinance exists); or
2. Two feet above the base flood elevation (BFE); i.e., 2 feet above the flood elevation having a 1 percent annual chance of being equaled or exceeded in any given year (100-year event); or
3. The stillwater flood elevation associated with the 0.2 percent annual chance of being equaled or exceeded in any given year (500-year event).

Residential Tornado Safe Room Exception: Where a residential tornado safe room is located outside of the hurricane-prone region as identified on Figure 3-2 of FEMA 361, and the community participates in the NFIP, the safe room need only be elevated to the minimum lowest floor elevation identified by the floodplain ordinance of the community.

Note, when installing a residential safe room in an area that has not been mapped or studied as part of a NFIP flood study (or equivalent flood study), the top of the safe room floor should be elevated such that it is 2 feet above the flood elevation corresponding to the highest recorded flood elevation in the area that has not been evaluated. Should no historical flood elevation data be available for the area, the elevation of the safe room floor should be set at the elevation identified by the local authority having jurisdiction.

In areas where Category 5 storm surges are not mapped, references in this publication to “Category 5” storm surge inundation areas should be taken to mean the area inundated by the highest storm surge category mapped.



New vs. Existing Homes or Buildings

The safe room designs in this publication were developed primarily for use in new homes or buildings, but some can be used in existing buildings. When a new home is being built, the builder/contractor can construct walls, foundations, and other parts of the home as required to accommodate the safe room. Modifying the walls or foundation of an existing home as necessary for the construction of a safe room is more difficult. As a result, some of the safe room designs in this publication are not practical for existing homes. Constructing a safe room within your home or small business puts it as close as possible to your family and/or employees. A safe room may be installed during the initial construction of a home or retrofitted afterward. As long as the design and construction requirements and guidance are followed, the same level of near-absolute protection is provided by either type of safe room. The following sections discuss these issues further. Also, for this discussion, the term “retrofit” refers to the process of making changes to an existing building.

It is relatively easy and cost-effective to add a safe room when first building your home or small business. For example, when the home is constructed with exterior walls made from CMUs (also commonly known as “concrete block;” see Figure II-5), the near-absolute protection level in FEMA 320 can be achieved by slightly modifying the exterior walls at the safe room space with additional steel reinforcement and grout. The safe room is easily completed by adding interior walls constructed of reinforced CMU, a concrete roof deck over the safe room, and a special safe room door, as shown in Figure II-6.



Figure II-5. CMUs were used for the exterior walls at this home under construction (New Smyrna Beach, Florida).

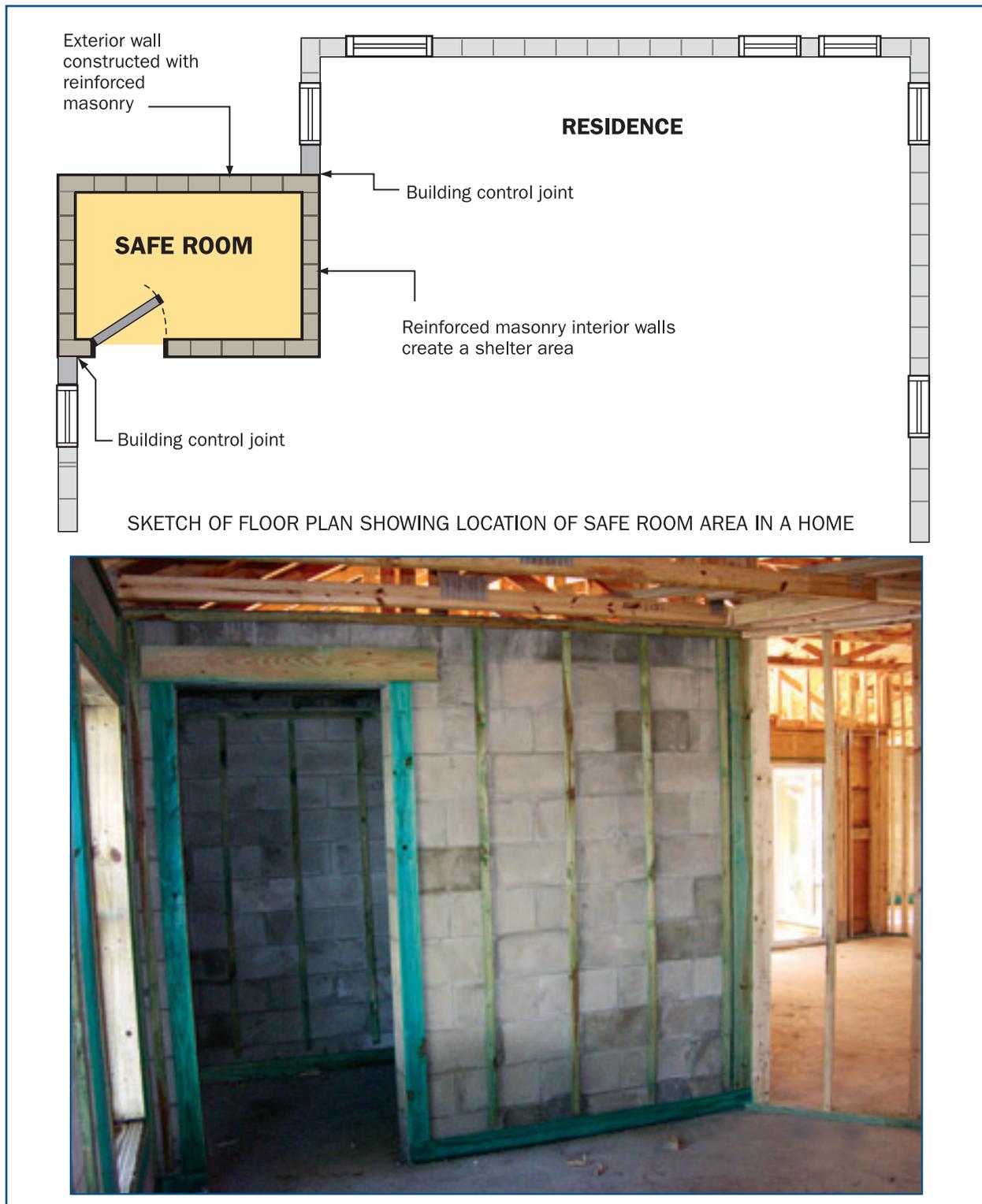


Figure II-6. View of an in-home safe room under construction. The CMU walls of this safe room are fully grouted and are reinforced, vertically, with steel reinforcing bars from the foundation to the concrete roof deck (New Smyrna Beach, Florida).



Building a safe room in an existing home will typically cost 20 percent more than building the same safe room in a new home under construction. Because the safe room is being used for life safety and your home might be exposed to wind loads and debris impacts it was not designed to resist, an architect or engineer (A/E) should be consulted to address special structural requirements (even when using an A/E in such a project is not required by the local building department).

Safe Room Location

There are several possible locations in your home or small business for a safe room. Perhaps the most convenient and safest is below ground level in your basement. If your home or small business does not have a basement, you can install an in-ground safe room beneath a concrete slab-on-grade foundation or a concrete garage floor. Although basement and in-ground safe rooms provide the highest level of protection against missiles and

falling debris because they may be shielded from direct forces of wind and debris, the above-ground designs provided in this publication are also capable of providing near-absolute protection. This is an important alternative to be aware of if you are not able to install a safe room in your basement due to concerns related to flood hazards or naturally-high groundwater tables at your site.

Another alternative location for your safe room is an interior room on the first floor of the home or small business. Researchers, emergency response personnel, and people cleaning up after tornadoes have often found an interior room of a home or small business still standing when all other above-ground parts of the home or small business have been destroyed. Closets, bathrooms, and small storage rooms offer the advantage of having a function other than providing occasional storm protection. Typically, these rooms have only one door and no windows, which makes them well-suited for conversion to a safe room. Bathrooms have the added advantage of including a water supply and toilet.



Regardless of where in your home or small business you build your safe room, the walls and ceiling of the safe room must be built so that they will provide near-absolute protection for you, your family, or employees from missiles and falling debris, and remain standing if your home or small business is severely damaged by extreme winds. If sections of your home's or small business' walls are used as safe room walls, those wall sections must be



separated from the structure of the home or small business. This is to ensure the structural integrity of the safe room, should the rest of the structure fail or be compromised during an extreme-wind event.

Figures II-7 through II-9 are typical floor plans on which possible locations for safe rooms are shown with yellow highlighting. These are not floor plans developed specifically for homes with safe rooms; they show how safe rooms can be added without changes to the layout of rooms.

Floor Plan 1: basement

Possible safe room locations in a basement include the following:

- In a corner of the basement, preferably where the basement walls are below ground level
- In a bathroom, closet, or other interior room in the basement
- In a freestanding addition to the basement

A space that is to be used for a safe room must be kept free of clutter so that the safe room can be quickly and easily entered and so that the safe room occupants will not be injured by falling objects. For this reason, a bathroom is often a better choice for a safe room than a closet or other space used for storage. Remember, if the basement is below the level of storm surge or the level of flooding from any other source, it is not a suitable location for a safe room. In this situation, a possible alternative would be to build an exterior safe room, adjacent to your home, on a slab-on-grade above the flood level.

Figure II-7.
Floor plan 1: basement





Floor Plan 2: safe rooms on the primary level of a home or small business

Possible safe room locations in a home on a slab-on-grade or crawlspace foundation include the following spaces on the first floor:

- Bathroom
- Closet
- Storage room
- Laundry room (provided the load-bearing wall between it and the garage, as shown in Figure II-8, can be properly separated from the structure of the home)
- Corner of the garage

Regardless of where the safe room is built, it must be equipped with a door that will resist the impact of windborne debris (missiles). Remember, if the first floor of the home or small business is in an area that is susceptible to storm surge from a Category 5 hurricane, it is not a suitable location for a residential safe room. Also, installation of safe rooms in SFHAs should only occur if the flood design criteria for FEMA safe rooms are met and approval has been provided by local jurisdictional authorities responsible for evacuating the area in the event of a hurricane and ensuring NFIP compliance. The prescriptive designs presented in this publication can only be elevated a few feet above existing grade and, therefore, may not comply with flood design criteria for residential safe rooms, which means the safe room designs presented in this publication should not be installed. In this situation, a possible alternative would be to build an exterior safe room on a slab-on-grade elevated on fill above the flood level.

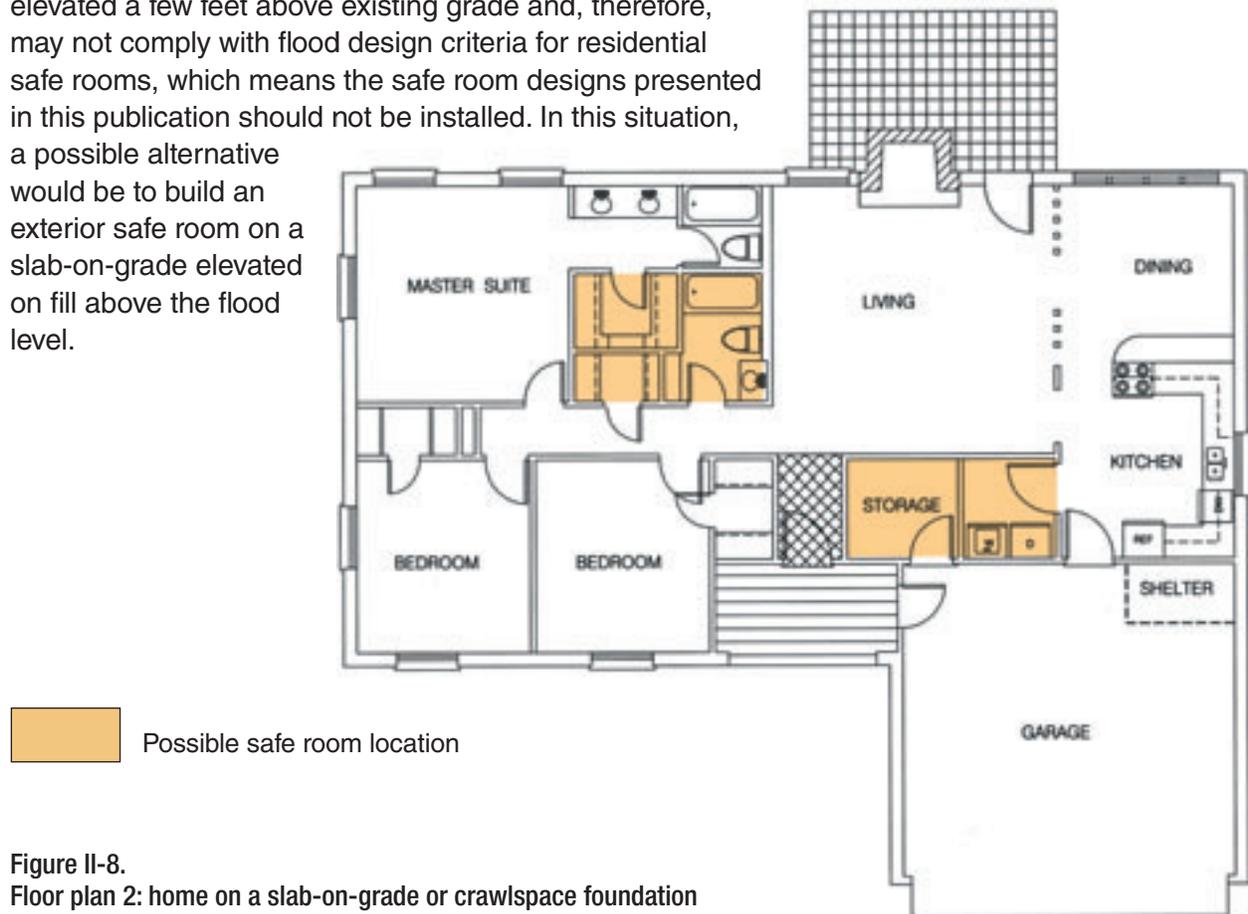


Figure II-8.
Floor plan 2: home on a slab-on-grade or crawlspace foundation



Floor Plan 3: below-grade safe rooms

Possible locations for an in-ground safe room include the following:

- Below the slab in a closet or storage room
- Below the floor of the garage, in an area where cars will not be parked

Because of the difficulty of installing an in-ground safe room in an existing home, this type of safe room is practical only for new construction. Remember, if the first floor of the home is in an area subject to storm surge or below the level of flooding from any other source, it is not a suitable location for a safe room. In this situation, see the previous section for guidance on a possible alternative to build an exterior safe room on a slab-on-grade elevated on fill above the flood level.

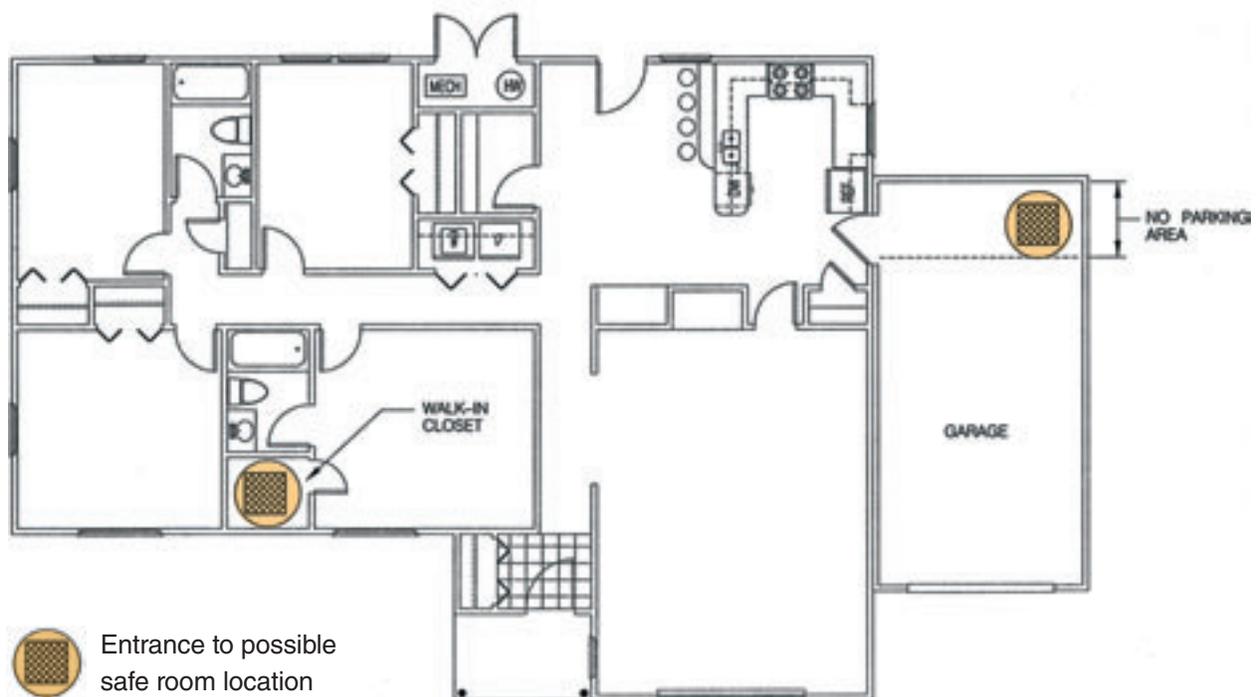


Figure II-9. Floor plan 3: in-ground (below-grade) safe rooms in a home on a slab-on-grade foundation

Floor Plan 4: multi-purpose safe rooms in a small business

Small businesses can use prescriptive safe room designs for multi-purpose safe rooms (see Figure II-10). Using a 14-foot by 14-foot safe room, the area used for life-safety protection can also be adapted for a conference room or other purpose, provided the equipment and fixtures placed in the safe room can be removed quickly and efficiently. When placing safe rooms in buildings larger than typical residential structures, the layout should be designed so that the safe room is quickly accessible from most areas on the floor. If a larger safe room size is desired, design guidance in FEMA 361 can be used.

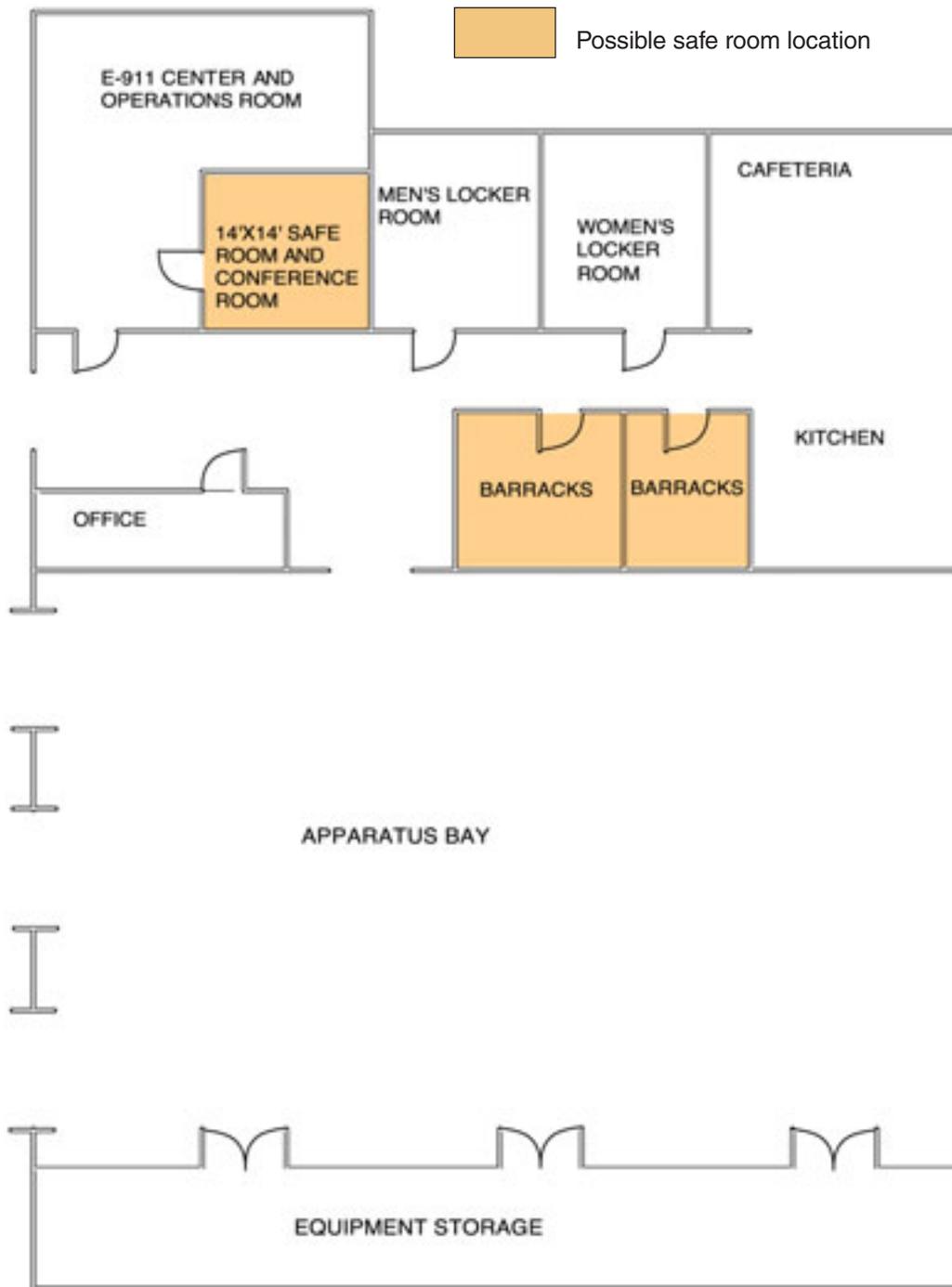


Figure II-10. Floor Plan 4: multi-purpose safe rooms in a small business or public building

Tables II-1 and II-2 will help you decide what type of safe room is appropriate for your circumstances. Table II-1 applies to the construction of safe rooms in new homes or buildings. Table II-2 applies to retrofit situations, in which a safe room is being added to an existing home or building.



Table II-1. Appropriate types of safe rooms for new homes and buildings

Safe Room Considerations (New Homes or Buildings)	Appropriate Safe Room Type		
	Basement	In-Ground*	Above-Ground
House or building located in a storm surge area	NA	NA	NA
House or building located in a flood hazard area ⁺⁺	NA	NA	✓
High water table			✓
Low cost	✓		
Long-term safe room occupancy comfort	✓		✓
Least likely to be hit or impacted by windborne debris	✓	✓	

Table II-2. Appropriate types of safe rooms for existing homes and buildings

Safe Room Considerations (Existing Homes or Buildings)	Appropriate Safe Room Type		
	Basement	In-Ground*	Above-Ground
House or building located in a storm surge area	NA	NA	NA
House or building located in a flood hazard area ⁺⁺	NA	NA	✓
High water table			✓
Low cost	✓		
Long-term safe room occupancy comfort	✓		✓
Least likely to be hit or impacted by windborne debris	✓	✓	
Easy retrofit	✓		
Ease of separating safe room from structural framing of house or building	✓	✓	
Minimal disruption to house or building	✓		
Ease of accessibility			✓

NA = Not Appropriate

* The in-ground safe rooms referred to in this publication are built below ground inside a home or building and therefore can be entered directly from within the home or building. Other types of in-ground safe rooms are available that are designed to be installed outside a home or building. Entering one of these exterior in-ground safe rooms would require leaving the home or building. This publication does not contain any designs or other information about exterior in-ground safe rooms.

⁺⁺ Per flood design criteria for FEMA safe rooms (see pages 23 and 24), elevation of a safe room is only permitted when specific flood design criteria have been met and when approved by the jurisdictional authority responsible for evacuations and NFIP compliance.



Construction Materials

The materials your builder/contractor will need to build your safe room should be available from building material suppliers in your community. These materials have been carefully selected for their strength, durability, and/or ability to be readily combined in ways that enable them to withstand the forces of extreme winds and the impact of windborne missiles. Your builder/contractor should not substitute any other material for those specified in the designs.

One of the most vulnerable parts of your safe room is the door. The WISE Center at Texas Tech University tested the materials specified for doors in the safe room designs in this publication for their ability to carry wind loads and prevent perforation by missiles. The installation of the door is as important as the materials used in its construction. Please confirm with your builder/contractor that the door to your safe room can be installed as shown in the design drawings included with this publication. A door specification has been provided in the plans if you cannot obtain a door that meets the debris impact testing requirements for a 15-lb 2x4 board member traveling horizontally at 100 mph (see ICC-500, Chapter 8 for the debris impact testing procedure to be used).

A complete list of the safe room construction materials, with their expected strengths or properties, is included in the safe room designs provided in this publication. Your builder/contractor should use it when buying the materials for your safe room.

There are other viable and appropriate shelters that have been designed and constructed to meet FEMA's design criteria for residential safe rooms that are not included in this publication. Since the first edition of FEMA 320 was released in 1998, many tornado events have occurred highlighting the importance of installing a safe room in homes or small businesses. Individuals and companies began designing shelters to provide alternatives to the prescriptive solutions presented here. As a result, a residential tornado and hurricane shelter industry has evolved.

Many of these shelter products are designed and constructed as pre-manufactured units. These pre-manufactured units are constructed from a variety of elements such as metal panels, fiberglass shells, Kevlar product systems, and many more. Others are shelters that use common building materials or are new innovations from the building industry such as structural insulated panels (SIPs). Because FEMA 320 was accepted as a "pre-standard" for the design and construction of shelters and safe rooms, many of these shelters have been designed to the FEMA criteria for residential safe rooms; that is, they are capable of resisting 250 mph winds (3-second gust) and the debris associated with such wind events (represented as a 15-lb 2x4 wood board traveling 100 mph).

It is important for prospective safe room owners to know that FEMA does not certify, approve, or license the design and construction of shelters to be

Structural Insulated Panels (SIPs) are a construction innovation that is being used in some residential construction. SIPs are composite building materials, consisting of two layers of structural board with insulating foam in between.

Some SIPs have been designed such that they are capable of resisting the design wind and debris impact criteria of FEMA 320.



Additional information regarding pre-manufactured shelters is presented in the Consumer Guide in Section III of this publication. It is important to remember that, as with site-built safe rooms and shelters, pre-manufactured shelters should be attached to an appropriate foundation. A structural engineer should always be consulted to ensure that the pre-fabricated shelter is being installed on an appropriate and adequate foundation.

called safe rooms. However, groups such as the National Storm Shelter Association (NSSA) have stepped forward to help regulate the residential shelter industry. Since the release of its Association Standard in April 2001 (*NSSA Standard for the Design, Construction, and Performance of Storm Shelters*), the NSSA has provided certifications for shelters that meet the FEMA 320 criteria in the form of a quality verification process and seal program. Through independent testing and third party design reviews, participating members of the NSSA have received “seals” indicating that their shelters have been designed to meet the wind and debris impact protection criteria of FEMA 320. As a result, many pre-manufactured shelters have been verified and labeled with “seals” indicating that they comply with the FEMA 320 residential safe room design criteria.

Therefore, when it can be verified that these pre-manufactured shelters are installed on a proper foundation, and are elevated and sited to meet the flood design criteria provided herein, these proprietary shelters can be viewed as an appropriate alternative to the designs presented in this publication.

FEMA supports the work of the NSSA to promote the design and construction of shelters that meet the near-absolute protection criteria set forth in this document. The efforts of NSSA allow individual or proprietary designs to be included in the market place and considered alongside the FEMA safe room designs as options for homeowners and business owners looking to provide protection from extreme-wind events that may impact their homes or buildings. For additional information on the NSSA and other shelter products that meet the FEMA criteria, see the Consumer Guide provided in Section III.

Safe Room Cost

When designed and constructed per the specifications on the design plans, these safe rooms meet or exceed the design requirements for tornadoes and hurricanes as identified in the ICC-500 Storm Shelter Standard. Pre-fabricated shelters are also available for installation by a builder/contractor when first building your home, but are not explicitly addressed by this publication. The basic cost to design and construct a safe room during the construction of a new home starts at approximately \$6,000, with larger, more refined, and more comfortable designs costing more than \$15,000. The cost of your safe room will vary according to the following:

- The size of the safe room
- The location of the safe room
- The number of exterior home walls used in the construction of the safe room
- The type of door used



- The type of foundation on which your home is built
- Your location within the United States (because of regional variations in labor and material costs)
- Whether you are building a safe room into a new home or retrofitting an existing home

Table II-3 shows the average costs for building two types of safe rooms (above-ground [AG] and in-ground [IG]) in new homes on basement, slab-on-grade, and crawlspace foundations according to the design plans in this publication. These costs are for safe rooms with a floor area of 8 feet by 8 feet and 14 feet by 14 feet.

Table II-3. Average costs for both 8-foot by 8-foot and 14-foot by 14-foot safe rooms in new homes or buildings

Size	Safe Room Type ^{1, 2, 3, 4}	Applicable Drawing No.	Average Cost ^{1, 3, 4}
8-foot x 8-foot x 8-foot Safe Rooms	Concrete Masonry Unit (CMU) Walls	AG-01,02,03	\$8,200
	Concrete Walls	AG-01,02,03	\$8,100
	Wood-Frame with CMU Infill	AG-05	\$7,600
	Wood-Frame with Plywood/Steel Sheathing	AG-06	\$6,300
	Insulating Concrete Form	AG-08,09	\$8,300
	Reinforced Concrete Box ²	IG-01	\$7,000
14-foot x 14-foot x 8-foot Safe Rooms	CMU Walls	AG-01,02,03	\$13,500
	Concrete Walls	AG-01,02,03	\$13,100
	Wood-Frame with CMU Infill	AG-05	\$13,600
	Wood-Frame with Plywood/Steel Sheathing	AG-06	\$11,400
	Insulating Concrete Form	AG-08,09	\$13,400

1 All safe room types shown in this table are above-ground (AG) types for slab-on-grade foundations. Safe rooms constructed in basements or on crawlspaces will differ slightly in price based on the foundations used.

2 Below-ground safe room were estimated for a 5-foot by 5-foot by 8-foot (deep) safe room. The cost included a cast-in-place footing and safe room top, but the safe room walls were a pre-cast unit. The costs for these types of safe rooms are very dependent on site-specific soil conditions and the building materials used.

3 See drawings in this publication for specific materials used, sizes, and other values needed for estimating purposes.

4 Costs provided are budgetary cost estimates calculated to 2008 U.S. dollar values.

The cost of retrofitting an existing home to add a safe room will vary with the size of the home and its construction type. In general, safe room costs for existing homes will be approximately 20 percent higher than those shown in Table II-3.



It is also interesting to note that the cost differential between constructing the combined tornado and hurricane safe rooms presented in this publication and those that may be constructed to meet the ICC-500 residential hurricane (only) safe room design criteria is not a significant cost savings. Construction cost comparisons for some of the common building materials used in the prescriptive designs of this publication were performed.

For the masonry and concrete safe rooms, wall and roof sections that were identified through testing as capable of resisting a test missile that had similar impact momentum as the ICC-500 design missile were selected. Because the ICC-500 is a new standard, very few tests have been performed for missile-resistant systems for the ICC-500 missile. Test results from Texas Tech University's WISE Center, Florida A&M University, Florida State University, and the University of Florida were used to identify wall sections that had been tested. For these types of safe rooms, the costs to construct the ICC-500 residential hurricane safe room typically provided a cost savings of only 10 to 15 percent when compared to the cost to construct the FEMA 320 safe rooms presented in Table II-3. Proprietary safe rooms were not included in this cost comparison as no pre-manufactured shelters meeting the new ICC-500 requirements were able to be identified.

These findings, however, were not surprising when considering the common building materials used. As was the case when the First Edition of FEMA 320 was prepared, the safe room design for these small safe rooms is typically governed by the ability of the walls and doors to provide debris impact-resistance. When considering the factors that are involved (250 mph vs. 160 mph design wind speeds and debris impact-resistance for different weight and speed missiles), the net savings is measurable but not large as the reduction of materials from the design is typically limited to a reduction in reinforcing steel, connectors, or wall thickness. For both the masonry and concrete safe rooms, there was still a basic wall thickness that needed to be provided to resist both the debris impacts and the wind loads.